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July 25, 1997

Ms. Kate Hansel
CALFED Bay-Delta Program
1416 Ninth Street, Suite 1155
Sacramento, CA 95814

Dear Ms. Hansel,

Enclosed please find an original plus nine copies of an inquiry proposal titled, "Shasta Temperature Control Device: Predicting Operation Effects." I will appreciate your evaluation of this inquiry proposal for consistency with the mission of the CALFED Bay-Delta Program.

If you have any questions, please call me at (916) 752-1424, or you may reach me via e-mail at gtorlob@ucdavis.edu. I look forward to receiving your reply.

Sincerely yours,

Gerald T. Orlob
Professor Emeritus
Civil and Environmental Engineering

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Inquiry Proposal

SHASTA TEMPERATURE CONTROL DEVICE PREDICTING OPERATION EFFECTS

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Project Description

Maintenance of desirable water temperatures for salmon spawning in the Sacramento River has necessitated changes in the normal operation of the Shasta-Trinity Division of the Central Valley Project (CVP) in order that colder water from the reservoirs may be selectively withdrawn during the late summer and early fall spawning periods. To provide greater flexibility for selective withdrawal at Shasta Dam and to avoid the loss of power potential when cold water must otherwise be supplied through low level outlets, the U.S. Bureau of Reclamation designed a temperature control device (TCD) that was installed in 1996 on the face of the dam. The TCD allows operational selection of withdrawal elevations corresponding to desired water temperatures in the thermally stratified reservoir.

Because the thermal structure of the reservoir changes seasonally and the quantities of cold water vary with hydrological and meteorological conditions, the operation of the TCD must be adjusted accordingly. The temperature of water withdrawn through the TCD will depend both on the elevations of gate openings and the stability of thermal strata within the impoundment that are, in turn, influenced hydrodynamically by withdrawal. Schedules of power production that may affect the internal dynamics of the reservoir and seasonal variability in hydrological and meteorological conditions are also important factors influencing TCD performance. The proposed project would provide the means to quantify operation effects and assess the efficacy of the device in meeting objectives for downstream temperature regulation.

Objectives

The principal objective of the proposed project is to provide the means to assess quantitatively the effects of operation of the TCD on the internal thermal structure and hydrodynamics of the reservoir and its reliability in meeting temperature targets in the Sacramento River downstream. Because the TCD has just recently been installed, data necessary for performance evaluation are not yet available. It is proposed that these be developed in the proposed project.

Approach

To meet the above stated objectives it is proposed to adapt an existing three-dimensional stratified flow model to simulate operation of the TCD over a range of hydrological, meteorological and operational conditions sufficient to test its effectiveness in passage of water of desired temperatures and to determine the corresponding response of the reservoir. Previous studies at UC Davis modeling in the Sacramento River Temperature Modeling Project provided one-dimensional descriptions of the thermal regime in Shasta Reservoir (see Figure 1 and 2). These, together withmodels of Keswick Reservoir and the hydrodynamic and temperature models of the Sacramento River below Keswick, will serve as a foundation for the proposed project wherein the complex dynamics of flow in Shasta Reservoir would be modeled three-dimensionally. For this purpose it is proposed the adapt the stratified flow model RMA10 to simulate the flow regime of the entire reservoir as it responds to hydrologic inputs, meteorological conditions, and operating schedules. RMA10 utilizes the finite element method to solve the equations of continuity and momentum for both steady and unsteady hydrodynamics. A companion model, RMA11, simulates water quality, including for this case heat exchange and transport. The finite element approach provides unique capabilities to capture the details of internal hydrodynamics and corresponding temperatures, such as in the vicinity of the TCD, that will be important in assessing the impact of the device on reservoir thermal stratification. Inputs required by the model include operation schedules of releases, hydrologic inputs and exports (withdrawals), and meteorological conditions. Outputs consist of temporal and spatial descriptions of velocities, flows, water levels, and water temperatures for points on a three-dimensional grid representing the geomorphic and bathymetric properties of the reservoir. The models proposed for this project have applied to the Bay-Delta estuarine system, to a large reservoir in New York state, and are currently being applied to the Salton Sea in southern California and to Whiskeytown Reservoir in the CVP system (UCD/USBR project in progress, 1996-1998).

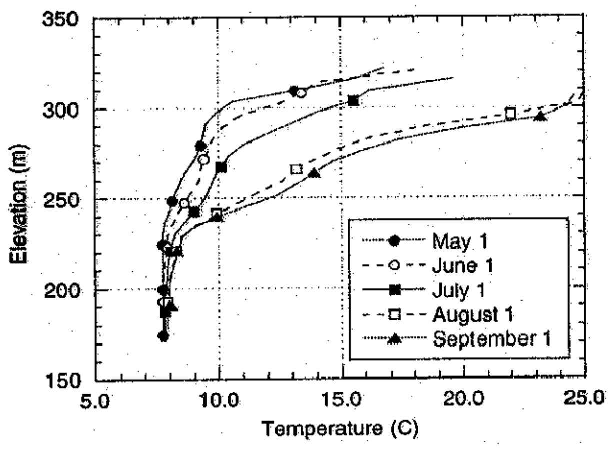

Figure 1. Illustration of Thermal Stratification Near Shasta Dam

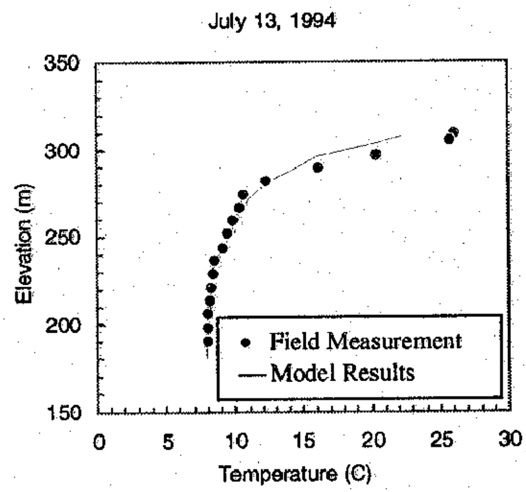

Figure 2. Modeled and Measured Water Temperature at Shasta Dam

Scope of Work and Schedule

To achieve the objectives stated above it will be necessary to complete a series of specific tasks which may include: (1) assemble and evaluate hydrological, meteorological, and operational data ; (2) develop the bathymetry of Shasta Reservoir; (3) construct a three-dimensional finite element grid representing the bathymetry of the reservoir; (4) conduct monitoring surveys of the thermal and hydrodynamic characteristics of the reservoir under selected operational conditions; (5) calibrate and verify models against prototype observations; (6) simulate TCD performance for selected operation conditions; (7) evaluate TCD performance against objectives; (8) develop guide lines for TCD operation; (9) document project accomplishments. It is expected that these tasks could be completed within a period of two years from the start of the project.

Expected Benefits

The principal benefit of the proposed project will be improved reliability of the Temperature Control Device on Shasta Dam in meeting downstream temperature targets.

Products

Three-dimension hydrodynamic and temperature models and a supporting data base will be available for application to Shasta Reservoir for continuing studies of reservoir operation.

Justification

The results of this project will provide added assurance of effective operation of the TCD to meet temperature control objectives for the benefit of salmon propagation.

Level of Effort and Budget Cost

It is estimated that the level of effort required over the two-year project period will be equivalent to three person-years at a cost of $120,000. With allowances for travel, supplies, equipment for field surveys, and overhead the total project cost is estimated at $180,000.

Applicant Qualifications

The project will be supported by many years of experience of Drs. G. T. Orlob and I. P. King in development and application of mathematical models of surface water systems, including original models such as proposed for this project. Graduate student participants in the project will be experienced in modeling and in the development of information in the field.

Program Coordination and Support

This project will be coordinated with ongoing projects at UC Davis supported by USEPA, USBR, USFWS and the California Departments of Fish and Game.